



Inventory of Significant Mineral Deposit Occurrences in the Headwaters Project Area in Idaho, Western Montana, and Extreme Eastern Oregon and Washington

By Gregory T. Spanski

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Metric Conversion Factors		
Multiply	By	To obtain
Short tons	0.907	Metric tons
Troy ounces	31.104	Metric tons
Cubic yards	0.7646	Cubic meters

Summary

The significant mineral deposit inventory supports the U.S. Geological Survey Headwaters project, which will provide Federal land management agencies with basic geologic and mineral resource information that can be used to manage near-term mineral resource development activity. The Headwaters study is focused on areas in Idaho lying north of the Snake River plain and in western Montana where a preponderance of the lands are managed by the U.S. Forest Service. The scope of this mineral resource inventory embraces a broader geographic area that includes all of Idaho, the western half of Montana and small portions of extreme eastern Oregon and Washington.

This inventory covers only significant mineral deposits. Significant deposits are those deposits where a mineral or natural material endowment occurs in such a high concentration that it is reasonable to expect that recovery was or could, in the future, be economically viable. Minimum endowments proposed by Long (personal communication) for 46 commodities have been used in this compilation. For deposits of other commodities where minimum endowments have not been established a default deposit size minimum of one million metric tons of ore has been utilized. A significant status has also been applied to deposits where a commodity or material is of a highly unusual nature.

Data collection was limited to deposit attributes that reflect directly on the endowed size and location of a deposit, and ancillary information that can be used in assessing regional mineral resource potential. The data are organized in topical information categories that include name, location, deposit classification, discovery date, production and resources, surface area, development status, and source of new information. Data were extracted from a diverse array of sources that includes scientific, technical, and trade publications of public and private institutions, organizations, and associations that follow and report on scientific, business, and environmental issues in the minerals industry; company financial reports, news releases, and technical reports available at company web sites; mineral information databases maintained by Federal and state agencies involved with monitoring and regulating mining activities and compiling mining industry statistics; and oral communications with individual mining company personnel and with staff of Federal and state regulatory agencies. Several formatting conventions are used to indicate what the relative accuracy of the numerical data is believed to be.

A total of 256 significant deposit sites are identified by location and deposit-type. Production and resource figures are given in both English and metric units and the approximate surface areas associated with three aspects of deposit development are expressed in acres. Of the 256 sites, 208 have some history of past or present production, of which 23 are currently producing and mining could resume at 7 others on short notice with a rise in commodity prices. Within the 208 sites are 34 placer districts and two zeolite operations wherein mining activity on a small scale occurs intermittently. There are 166 sites where the presence of a significant resource has been recognized, of which 49 have no prior history of development. Due to the presence of a significant resource, these 166 sites are candidates for consideration when addressing issues associated with management of near-term mineral development.

Introduction

Since the early 1800s, United States policy and legislation have encouraged mineral resource development on Federal lands in the western United States, where mining has played a prominent and near continuous role in the development of many local economies. Recurrent and ongoing exploration activity suggests that mining will continue to play a role well into the foreseeable future. However, growth in local populations and diversification of local economies, along with societal concern for the preservation of the natural environment, has generated pressures that are bringing about change. All phases of mineral development from initial exploration through final site reclamation are being subjected to higher levels of oversight and increased regulation to ensure that environmental impacts are minimized. In turn, the administrative planning that supports the programs that are used to manage minerals development requires more comprehensive and detailed geologic and mineral resource input.

In the 1960s, the Geological Survey used a qualitative approach to mineral resource appraisal studies that provides much of the geologic and mineral resource information used in management planning. A high, moderate, and low classification nomenclature was used to characterize resource potential. In the 1980s, with the formalization of the concept of deposit-types and deposit models, a quantitative analytical component was added to

the resource appraisal process. A deposit-type is a categorical representation of an aggregation of deposits that are physically similar, occur in similar geologic settings, and are believed to have been formed by similar geologic processes. The deposit model describes the physical characteristics and grade and tonnage variations that are associated with the economically interesting occurrences belonging to a particular deposit-type. Quantification of potential for a deposit-type is achieved using the grade and tonnage models and intuitive estimates for the numbers of undiscovered deposits of a deposit-type that are likely to be present within a specified area. Since the early 1990s mineral resource studies have addressed the need for mineral resource potential information with products that include maps depicting tracts with mineral deposit potential, frequency distribution curves that characterize the commodity endowments associated with undiscovered deposits, and probabilistic estimates of the numbers of undiscovered deposits of each deposit-type that is likely to be present.

The Headwaters study is representative of this newest type of assessment. It is deposit-type based and delineates mineral resource potential tracts; however, it differs from other assessments in that numbers of undiscovered deposits and quantitative commodity endowment estimates are not included. At the outset of the study, land managers for areas of Idaho and western Montana covered in the Headwaters study indicated that they were interested in near-term mineral development issues and in acquiring qualitative information that could be used in planning. The quantitative approach of estimating undiscovered deposits and modeling endowments is not time dependent; the estimates do not address when the indicated deposits might be discovered. Therefore, to address the near-term potential, analyses of trends in industry interest in specific deposit-types using claim holdings and exploration data and studies of the spatial distribution and grade and tonnage characteristics of local deposits by deposit-type using significant deposit production and exploration data, are included. These products are more likely to identify deposit-types of near-term interest, highlight areas where rising commodity prices or technologic innovation could turn an identified marginally economic resource into an economic reserve, or stimulate exploration interest in areas where the probability for the existence of additional deposits of a deposit-type is favorable.

The significant deposits database contains commodity endowment-related information for developed and undeveloped mineral properties occurring in Idaho, western Montana, and the extreme eastern portions of Oregon and Washington. Much of the content is based on the significant deposit studies of Ludington and Cox (1996) and Long and others (1998), which covered larger geographic areas, but were limited in the commodities that they covered. In the current tabulation the commodity coverage has been expanded, and where data on more recent activity is available, production and resource and reserve figures have been revised. The use of district type records has been reduced. Many of district records appearing in earlier compilations have been eliminated or replaced by more site-specific records that emphasize the characteristics of properties that would be mined as a unit by a single operator. An additional category has also been added that describes some of the property or site acreages that are associated with exploration and development of a deposit.

Significant Deposits

The term “significant” when used in conjunction with mineral deposits has acquired a more definitive meaning as a result of studies by Singer (1995) in the early 1990’s. He studied the relationship between the quantitative distribution of the world’s discovered resources for five commodities (gold, silver, copper, lead, and zinc) and the size (weight of mineralized rock that contains the resource) of the deposits in which those resources occur. The results reaffirmed the economic importance that large tonnage deposits play in the supply of these commodities. For each commodity category, deposits of median size and larger account for more than 98 percent of the known world resource. He also observed that, for exploration and economic planning purposes, smaller tonnage deposits are of little significance in contributing to world mineral supply and have little affect on commodity pricing or the foreign exchange of the countries in which they occur. As an outgrowth of Singer’s work, a set of minimum deposit endowment values has been adopted that is used to distinguish what have come to be known as “significant deposits” for gold, silver, copper, lead and zinc. Long (personal communication) has extended the concept of the significant deposit by establishing endowment threshold values for 41 additional commodities. Endowment threshold values for significant deposits for commodities encountered in deposits in the Headwaters study are listed in Table 1. In those few situations involving commodities for which no significant endowment threshold value has been established, as a general rule, the deposit is deemed significant if it contains more than one million metric tons of mineralized material. Exceptions to this rule are made for deposits of lesser size, where the commodity involved is valued for some unique property it possesses or the value of the deposits has been demonstrated through a history of productivity. For example, no minimum endowment value has been established for either opal or sapphire; however, deposits of both, some containing less than a million metric tons of mineralized material, occur in the Headwaters study area and are cited in the database due to their histories of recurrent productivity.

Table 1. Minimum commodity endowment requirements for a deposit to be considered significant in metric tons (mt)

Commodity	Minimum Endowment ¹	Commodity	Minimum Endowment ¹
Aluminum oxide	na	Nickel	7,000 mt Ni
Antimony	22,000 mt Sb	Opal	na
Arsenic	11,000 mt As	Palladium	na
Bismuth	na	Perlite	2,400,000 mt crude perlite
Cadium	18,000 mt Cd	Phosphate rock	4,000,000 mt phosphate rock
Chlorite	na	Platinum	3 mt Pt
Chromium oxide	na	Pumice	4,000,000 mt crude pumice
Cobalt	1,400 mt Co	Sapphire	na
Copper	<i>50,000 mt Cu</i>	Selenium	na
Fluorite	1,000,000 mt crude fluorspar	Silver	<i>85 mt Ag</i>
Garnet	1,300,000 mt crude garnet	Sulfuric acid	na
<i>Gold</i>	<i>2 mt Au</i>	Talc	na
Iron	na	Telurium	na
Kyanite/andalusite	350,000 mt crude kyanite	Tungsten oxide	5,044 mt WO ₃
<i>Lead</i>	<i>35,000 mt Pb</i>	Vermiculite	600,000 mt crude vermiculite
Manganese ore	36,000,000 mt Mn ore	Zeolite	2,000,000 mt crude zeolite
Mercury	7,000 mt Hg	Zinc	<i>50,000 mt Zn</i>
Molybdenum	12,000 mt Mo		

1 - italicized values after Singer, 1995; na - not available.

The significant deposits are well suited for addressing near-term future mineral development issues. The minimum significant commodity endowment values separate a population of currently economically viable deposits and marginally economic occurrences (low grade and very high tonnage or high grade and small tonnage) from a population of lesser-endowed occurrences with little or no economic potential. The marginally economic deposits include a mix of prospects and some prior producing mines. The prospects would be those having a high probability of becoming economic through either a modest rise in commodity pricing or development of new mining or milling methods that would reduce processing costs. The previously producing mines would include deposits that would not likely be economically developable today due either to a decline in commodity pricing or when the economic impacts of meeting modern era environmental requirements and restrictions are considered. Significant deposits characterize the mineral resource occurrences that concern land managers the most; those whose economic viability are most sensitive to near-term price and cost changes.

Local or regional significant deposit data can be used to assess the potential for undiscovered significant deposits. Where a substantial amount of significant deposit data is available, local grade and deposit size (tonnage) models for specific deposit-types can be created. These models are specialized. They define the grade and tonnage variation present in a sampling of significant deposits, whereas traditional global models depict the variation present in a more robust sampling that commonly includes a component of non-significant deposits. Either set of models can be used in the subjective process of estimating undiscovered deposit potential, given the understanding that the economic character of the potentials being estimated differ. Local deposit data can also be tested to determine the probability that the grade and tonnage of a local sample population compares with a globally robust deposit-type deposit population. Such tests can determine how suitable a global model may be for estimating undiscovered deposit potential and whether modification of the global model using local data should be considered. In situations where interest is focused on near-term activity, a set of models that is based on a subset of significant deposits may be more appropriate.

Acknowledgments

The information contained in this inventory is drawn from a host of sources that include Federal and State agencies responsible for monitoring and regulating mining and mining-related activity. The author is deeply indebted to the many local and regional staff members of the U. S. Bureau of Land Management and U.S. Department of Agriculture, Forest Service located in offices in Idaho and Montana, to staff of the Idaho Department of Lands and the Montana Department of Environmental Quality, and to individual mining company personnel who have so graciously shared information that was not of a proprietary nature. However, the accuracy of the information contained in the inventory remains the sole responsibility of the author and users are encouraged to bring errors or corrections to his attention. He may be contacted by mail at US Geological Survey, Box 25046, MS. 973, Lakewood, CO 80225, by telephone (303) 236-5705, or e-mail gspanski@usgs.gov.

Database

The significant deposits database contains site information concerning location, form of mineralization, production history, remaining resources, property size, and current development status. The structure and content is heavily influenced by an earlier effort undertaken by Long and others (1998) to compile an inventory of significant deposits for the United States. Many of the attribute fields and information found in that database have been retained. However, some changes have been made for purposes of including other categories of data. Specifically, fields have been included to report on additional commodities beyond the five covered in the Long and others (1998) compilation, and to track the size of various surface areas that are associated with deposit-related exploration and development. Production and resource data for properties active since 1996 have been revised, where the information is available, and emphasis has been placed on reporting resources as opposed to reserves, where both resource and reserve data are available. Resources are those concentrations of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible. Reserves are that part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth, which could be economically extracted or produced at the time of determination.

Individual deposit records in the database are deposit-type based. Cox and Singer (1986) defined a deposit to be "a mineral occurrence of sufficient size and grade that it might, under the most favorable circumstances, be considered to have economic potential". This definition, however, does not address the complex issue of deposit-types that may be involved with a mineral occurrence. Due to the complex nature of the processes that generate mineral occurrences, deposits may be categorized as either simple or complex. Simple deposits are those mineral occurrences where all of the mineralization present is characteristic of a single deposit-type, whereas complex deposits contain mineralization that is characteristic of a mix of several deposit-types. Deposit-type based records are of importance where deposit-type modeling is used to assess mineral resource potential. The integrity of deposit-type grade and tonnage models is predicated on the utilization of grade and tonnage data that is representative of mineralization associated with a single deposit-type. A single record is adequate for recording the data for simple deposit sites; however, multiple records can be required to properly document complex deposit sites to ensure the single deposit-type integrity of the data.

Prior to the early 1900s, the state of mining technology limited most mining development to mineralization (ores) of a single deposit-type, even in cases where other deposit-type mineralization was present. Advances in mining and milling technology throughout the 1900s made development of additional deposit-types possible. In many cases this has resulted in the reintroduction of mining activity to areas in and adjacent to previously mined sites where complex deposits occur. Generally, single records are used to document the attributes of a site where a significant endowment is contained in one or a cluster of closely spaced deposits of the same deposit-type, simple deposits. Single records are also used with the sites of complex deposits where production and (or) resource records do not permit the endowment to be partitioned between the deposit-types present, or where it can be shown that the significant endowment is predominantly associated with just one of the deposit-types present. In situations where it can be shown that there is a significant endowment associated with several of the deposit-types present at a site, separate records with unique deposit names are created for each deposit-type.

The use of site records severely limits the utility of “district” records. These records have been used in the past to quantify mineral production in areas where production records for individual mines are not available or production data has been purposely been aggregated to preserve confidentiality. One concern with these records is that aggregation can create a sense of significance through the cumulative effect of totaling production for many small, dispersed mines where in fact no true single deposit of significant size exists. The information in a “district” record has only been retained, where it can be shown that the mine data being aggregated pertain to a group of closely clustered mines that could be developed as a unit by one operator today, in which case a more appropriate deposit-relevant name is substituted. One exception to the single site record rule is allowed where placer “district” records are involved. Records of this type occurring in the Long and others (1998) database have been retained largely intact, because individual claim or property production records are virtually non-existent and the deposit site concept is less workable where placer operations are involved.

The data are contained in a single Excel 2000 spreadsheet file (HWSignDep.xls) and a Word 2000 file (HWSignDepDBRef.doc) contains a listing of the references cited in the spreadsheet. The geographic area of coverage includes all lands in Idaho, Montana, Oregon and Washington lying between the 109th and 118th West meridians. A total of eleven data categories containing from one up to 34 attribute fields are used to characterize deposit sites. A general summary of the types of attribute fields that are included in the database is given in Table 2. A mix of text and numeric entry formats is used. Latitude, longitude, property area, deposit area, disturbed area and all commodity production and resource attribute fields use a numeric entry format; all other fields use a text (character) entry format. Embedded formulae were used during the database compilation to convert production and resource values from the English to the metric system to ensure accuracy but they were purged from the final version. The HWSignDep.xls contains 172 attribute fields and 256 records. A set of alternate 10 character attribute field headers has been included and a 256-character limit on cell entries imposed to facilitate converting the database to a dbf file format, which is readily convertible into a shape file format for graphic display. Several formatting conventions are also used to convey information about data accuracy. A yellow background fill highlights values of questionable accuracy or those representing median values in a range of values. In the latter case, the range values are given in the comment fields. Vertical offset of a value in a cell is used to indicate that the value is a minimum or maximum. An offset to the top of a cell indicates the value is the maximum value in an unspecified range, and an offset of value to the bottom of a cell, that it is the minimum value in an unspecified range.

Table 2. Significant deposits database attribute field descriptions

Attribute Field Name	Format	Length	Description
Deposit Name	text	30	Name most commonly used in referring to the site. Other names used are enclosed in ().
Mining District/Area	text	30	Most commonly used name for the mining district or area in which the site occurs. Alternate district or sub-district name(s) are enclosed in ().
County	text	20	County in which site location coordinates plot. Name(s) of other county(ies) in which lands associated with the site occur are enclosed in ().
State	text	2	State in which the site location point for the site occurs. ID=Idaho, MT=Montana, OR=Oregon, WA=Washington
Longitude	num	9	Site location coordinate value in decimal degrees rounded to 4 decimal places. Negative in western hemisphere.
Latitude	num	7	Site location coordinate value in decimal degrees rounded to 4 decimal places. Positive in the northern hemisphere.
Deposit-type	text	30	Name of deposit classification category that best characterizes the dominant form of mineralization present. Italicized entry indicates that the U.S. Geological Survey deposit model classification system (Stoeser and Heran, 2000) is used. (unclassified=mineralization can not be classified)
Model No.	text	4	Deposit-type model number following U.S. Geological Survey deposit model nomenclature (Stoeser and Heran, 2000). (na=number not available)
Alternate Deposit-type	text	30	Name of deposit classification category that characterizes a prominent secondary form of mineralization present or alternate interpretation for the dominant form of mineralization. Italicized entry indicates that model nomenclature following the U.S. Geological Survey deposit model classification system (Stoeser and Heran, 2000) is used.
Alternate Model No.	text	4	Deposit-type model number following U.S. Geological Survey deposit model nomenclature (Stoeser and Heran, 2000). (na=number not available)

Environmental Model	text	30	Name of the geo-environmental model (duBray, 1995) applicable for the deposit-type present.
Discovery Year	text	9	Year in which mineralization was first recognized or first claims were staked.
Year Production Start	text	4	Year in which production was initiated.
Year Production End	text	4	Year in which the last production occurred. (present=indicates production was ongoing in 2003)
Ore	num	15	Quantity of mineralized material from which the commodity production was extracted, measured in English units. (na=information not available)
Ore Units (English)	text	10	Unit of measure for Ore. (st=short ton, cu yd=cubic yard)
Ag (oz)	num	12	Example of first of 34 commodity production fields. Quantity of commodity (Ag in example) produced during the production year interval measured in designated units (oz=ounces Troy, lbs=pounds avoirdupois, st=short tons, cts=carats). (blank=no production)
Other Commodities	text	16	Commodities recovered for which quantitative records are not available.
Production References	text	30	Source(s) of production information.
Resource Year	text	9	Year the resource estimate was announced.
Resource	num	15	Quantity of mineralized material containing potentially recoverable levels of one or more commodities. Precedence is given to reporting resources. Reserve estimates recorded only where resource estimates are not available. Where both categories are available, reserve estimates are noted in the comment fields. (na=information not available)
Resource Units (English)	text	10	Unit of measure for Resource. (st=short ton, cu yd=cubic yard)
Ag (opt or opcyd)	num	12	Example of first of 34 commodity grade fields. Estimated average commodity grade of the resource (Ag in example), measured in designated units (opt=ounces Troy per short ton, opcyd=ounces Troy per cubic yard, %=percent, ctyd=carats per cubic yard, ctpst=carats per short ton). (blank=not present, na=recoverable but grade not available)
Other Commodities	text	16	Commodities present that may be recoverable with no announced grades.
Resource References	text	30	Source(s) of resource information.
Comment (1)	text	256	First of three comment fields containing information or values related to data entered in other attribute fields. Individual fields limited to 256 characters.
Operator	text	30	Name of entity(ies) involved in the most recent development or exploration of the site.
Ore (in 1000's)	num	12	Quantity of Ore expressed in thousands of designated metric units. (0=no production, na=information not available)
Ore Units (metric)	text	10	Unit of metric measure for Ore. (mt=metric ton, cu meter=cubic meter)
Ag (t)	num	12	Example of first of 34 commodity production fields. Quantity of commodity (Ag in example) produced expressed in metric or other designated units (t=metric tons, Kt=thousand metric tons, Kct=thousand carats). (0=no production).
Resource (in 1000's)	num	12	Resource restated in thousands of resource units (na=information not available, 0=no resource). (t=metric tons, Kt=thousand metric tons, Kct=thousand carats)
Resource Units (metric)	text	10	Unit of metric measure for resource. (mt=metric ton, cu meter=cubic meters)
Au (t)	num	12	Example of first of 34 commodity endowment fields. Estimated quantity of commodity contained in the resource (Ag in the example) stated in metric or designated units (t=metric tons, Kt=thousand metric tons, Kct=thousand carats). (0=no resource present, na=information not available).
Property Area (acres)	num	10	Site surface acreage owned or controlled (leased or claimed) in conjunction with the development or exploration of a deposit. (blank=information not available).
Deposit Area (acres)	num	8	Site surface acreage that directly overlies the deposit or mineralized material (mined body or resource). (blank=information not available)
Disturbed Area (acres)	num	8	Site surface acreage disturbed or permitted for disturbance during mining.
Development Status	text	20	Description of the current status of mineral development. (active=ore mined within the last 12 months; inactive=no mining in last 12 months, workings and infrastructure under care and maintenance; closed=workings abandoned or final reclamation in progress or completed; prospect=significant resource defined by exploration; intermittent=placer area subject to sporadic intervals of mining activity)
Best Source (for updates)	text	20	Source where current site-specific production, resource and property information can be obtained.

The name most frequently cited in reference documentation is given preference in the **deposit name** field. In cases where the endowed resource in a deposit has only been partially developed and a remaining resource is

identified, the name associated with the larger resource is identified. Hyphenated names indicate that the information in the record represents an aggregation of data for a cluster of mining properties that have been unitized for reporting purposes. The names are those of the major contributing mines. Other names applied to a site are enclosed in parentheses.

Site locations are identified by **mining district/area**, political subdivision (**county** and **state**) and geographic coordinates (**longitude** and **latitude**) in the location data area of the database. Mining district nomenclature follows that used by the U. S. Bureau Mines for reporting mine production as modified by the Idaho and Montana Bureaus of Mines and Geology. Sub-district and district names that are no longer in common use but are encountered in reference documentation are noted in parentheses. Multiple states and counties are listed where the surface area of a site overlaps political jurisdictions. The longitude and latitude coordinates used to register a site location are expressed in decimal degrees with four decimal place precision. The more commonly used registration points used are the approximate geometric center for an undeveloped property, the main entry portal for an underground mine, and the geometric center of the surface workings for a surface mine. Departures from this convention are noted in the **comment** fields. Coordinates are based on the North American datum of 1927.

Information categorizing deposits in terms of the descriptive characteristics and the geo-environments with which they are typically associated are contained in 5 attribute fields grouped under the heading "Deposit Model Data". The classifications follow mineral deposit-type and geo-environmental model classification schemes developed by the U.S. Geological Survey in the 1980s and 1990s. Members of a deposit-type share a common set of physical characteristics and are found occurring in similar geologic environments. These physical characteristics and geologic settings are summarized in descriptive models. The average grades and tonnages of a sample population of member deposits, whose resource endowments have been defined through exploration and (or) development, are graphically displayed in cumulative distribution models. Given the fact that exploration is generally driven by expectations for economic reward, an assumption has been made that the models characterize those deposits of a deposit-type that possess at least some marginal degree of economic potential. The **deposit-type** field is used to identify the dominant form of mineralization present. Names following the deposit model nomenclature used by the USGS (Cox and Singer, 1986; Bultman, 1991; Orris and Bliss, 1991; Bliss, 1992; Bliss, 1994; Ray, 1995; Höy, 1996; Stoeser and Heran, 2000; Theodore, 2000; and Cox and others, 2003) are used where appropriate and the corresponding model number is entered in the **model no.** field. The **alternate deposit-type** field is used to recognize either the existence of a significant secondary type of mineralization or provide an alternate classification for the dominant type of mineralization where agreement on classification is lacking. In cases where the type of mineralization has not been formally modeled, a descriptive name is entered in italics in the deposit-type fields. Where the type of mineralization is so poorly understood that even a descriptive name cannot be assigned, the term "unclassified" is entered. In both of these instances a "na" (not available) notation is entered in the model number fields. The entry in the **environmental model** field identifies the geoenvironmental model (duBray, 1995) that best describes the pre-mining and post-mining environmental signature that is associated with the deposit-type.

The **discovery year** identifies the year the mineralization was first recognized or when the property was first staked. The **year production start** and **year production end** fields identify the period during which the ore and commodity production occurred, commonly on an intermittent basis. A production end date does not necessarily mean that mining at a site has ceased, only that production figures for any subsequent years have not been released to the public. Such may occur where a property is transferred to private owners, who are not required to release production information to the public. For sites having very recent production end dates and a development status that is active, production data for the intervening years may be obtainable from corporate financial records if the company's stock is publicly traded. Currently active mines are identified in the **development status** field.

Information related to mineral endowment is stored in commodity production and resource attribute fields, grouped in the production and resource data areas of the database. Values entered in these fields are based on publicly available records. Production for individual deposits may be understated where some production may have been withheld or production records have been lost or are incomplete. The publicly available information has been obtained from a wide variety of sources that include company reports, mining district studies, mine reports, and state and federal annual mineral production records. The accuracy of the production numbers contained in these sources cannot be guaranteed. Most pre-1900 commodity production is measured in terms of the sale value of the produced commodities. Many mine and mining district studies and mine published in the early 1900s contain commodity sales figures for the cumulative pre-1900 production that are estimated and subject to unknown error. Average commodity prices for the period are used to convert to an equivalent weight of production. Production figures are also affected by rules and policies regarding confidentiality. Publicly traded companies are required to disclose their production,

whereas privately owned and closely held companies have a right to treat production information as confidential and withhold it from disclosure. However, it is assumed that the production information contained in reports filed with regulatory agencies is fairly accurate. Cell formatting conventions cited earlier help to identify less reliable and questionable data.

The production and resource data are reported in both English units and in metric units in separate areas of the database. Embedded formulas were used to convert English units to metric units, minimizing computation errors. In the production area **ore** is generally reported in short tons (st) and thousands of metric tons (kilotons). A volumetric measure in cubic yards and cubic meters is used, where placer type deposits are involved, although, for most placer deposits information on the quantities of gravels processed is not available. Commodity production is reported in ounces Troy (oz), pounds (lbs), or carats (ct) and in metric tons (t), thousands of metric tons (Kt), or thousands of carats (Kct). A blank cell in a production attribute field indicates that there is no recorded value for that attribute. “Na” indicates that some substantial quantity of ore or a commodity has been produced but a measure of the amount is not available and cannot be estimated. Commodities that have been acknowledged, as having been produced in negligible amounts for which there is no record or estimate of production are listed in the **other commodities** field. The sources from which the production data are obtained are listed in the **production references** field.

Fields in the resource data category contain information concerning the resource endowments that are contained in undeveloped deposits or that remain in the ground and in stockpiles at the sites of deposits that have a prior history of development. Although a resource, in a general sense, is defined to be “a concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth’s crust in such a form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible”, demands from commercial and resource management interests have added complexities to their quantification. Unlike production, which is a physically distinct quantity, a resource is highly variable and its quantification is dependent on assumptions that are made concerning the economies of extraction and the certainty of how well its existence is known. In 1980, the U.S. Bureau of Mines and the U.S. Geological Survey (1980) published a classification system and nomenclature (fig. 1) based on these two parameters. In this system, a matrix of resource sub-categories are created, in which the terms “economic”, “marginally economic”, and “sub-economic” are used to denote declining economic viability and “measured”, “indicated”, “inferred”, “hypothetical” and “speculative” are used to denote decreasing degrees of certainty with respect to existence. Widespread acceptance and use of this classification scheme and nomenclature has improved uniformity in resource reporting and provides a more consistent basis for comparing and aggregating resource information.

Figure 1. Major elements of mineral-resource classification (after USBM and USGS, 1980)

Elements of Mineral Resource Classification (after CSRM and CRSE, 1999)						
Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES		
	Demonstrated		Inferred	Hypothetical	Speculative	
	Measured	Indicated				
ECONOMIC	Reserves		Inferred Reserves			
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves			
SUB-ECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources			
Other Occurrences	Includes nonconventional and low-grade materials					

Resource information in the database is limited to reporting on identified resources only. The data have been obtained from sources that cover an extended period of years that, in part, pre-date development of the newest classification system and include resource numbers that are based on a variety of economic and non-economic suppositions. Rarely are resources reported in more than one classification category. With undeveloped deposits, where the quantity and grade of the resource is commonly known with less certainty and economic feasibility has

not been tested, the resource is reported in one of the “resource” categories. The remaining resource associated with a more thoroughly developed deposit is known with a higher degree of certainty and is reported using one of the “reserve” resource categories. In this compilation, precedence is given to reporting “resources” in the **resource** and commodity grade (**Ag (oz)**, etc) attribute fields. In those few cases, where estimates of both “resources” and “reserves” for a deposit are available, the quantity and average grade of the combined “resources” are reported and the values for the “reserves” portion is noted in the **comments** field. In the English units area of the database mineralized material is reported in short tons, or cubic yards and the average commodity grades of the mineralized material in the commodity grade fields in ounces per short ton or cubic yard, carats per short ton or cubic yard, carats, or in percentage. In the metric units area, the **resource** is converted to thousands of metric tons, or thousands of cubic meters and commodity endowments are reported in metric tons, thousands of metric tons, or thousands of carats computed using the resource and commodity grade data. Blank cells indicate that the commodity is either absent or a grade has not been made public. “Na” indicates that a substantial resource or commodity endowment is known to be present but a measure of the amount is not available and cannot be estimated. Commodities that have been acknowledged to be present in the mineralized material, and are expected to be recoverable in small amounts are listed in the **other resources** field.

The surface area section of the database contains information concerning aspects of surface ownership, control and disturbance that is associated with the exploration and development of a deposit. This information is included because it addresses an area of growing importance to land and mineral managers. It is expected that, when a sufficient volume of data is accumulated, deposit-type based acreage models can be produced and that these models will be used to estimate surface area impacts that would likely to be associated with exploration and development of new deposits. Three types of surface data are stored; **property area**, the total surface acreage that is owned or controlled through leases or claims, a **deposit area**, the surface that immediately overlies the deposit, and a **disturbed area**, the area that is disturbed or is expected to be disturbed during development. The high proportion of blank cells found within the data fields reflects on the difficulty of obtaining this information, particularly for older properties, and explains in part why this category of information has not appeared in previous data compilations. However, since the 1960s, owners and operators are more frequently including surface-related information in project reports and annual operations summaries.

Property areas, as distinguished from deposit areas, have only entered into prominence during the last half-century. Prior to this time, the area of surface ownership or control associated with the development of a deposit was limited to a block of patented claims that secured rights to the deposit and a modest buffer of unpatented claims. Changes in exploration methods and capital costs associated with exploring and developing large tonnage and low grade types of deposits requires consolidation of control over much larger tracts of land in advance of substantial exploration. These property holdings tend to be at their greatest at the outset of exploration and often gradually diminish in size as exploration defines the area of the deposit. For project areas, emphasis is placed on citing the acreages that describe the property holdings on the date when the resource information was released, and for producing or past producing properties the acreage is an average for properties held during the period of production.

Deposit area is intended to represent the surface area that directly overlies a deposit. However, because this measure is rarely documented in mine records, many of these acreages are approximated. For deposits operating during the 1800s and early 1900s, the acreage of patented lode claims is used to approximate these areas. For most deposits explored or developed since the early 1900s, there is a more generous supply of published documentation that includes geologic investigations, exploration progress reports, feasibility studies, operations plans, environmental mitigation studies, and annual industry summaries of company activities from which the size of the deposit area can be inferred with a high degree of accuracy.

The information contained in the **disturbed area** field identifies acreage that has been disturbed by mining activities or is expected to be disturbed. Areas for older mining operations are approximated from patented lode and mill site claim holdings. For more recent operations, much of the data can be acquired from regulatory permits that stipulate what area limits on disturbance are allowed.

The current status of activity at a deposit site is posted in the **development status** field. A minimal set of five status categories is used. *Closed* indicates an operation that has been shut down and is not expected to be re-started. *Active* and *inactive* indicate, respectively, sites where mining is ongoing and subject to only brief or seasonal interruptions in activity, and sites where operations have been suspended for an appreciable period but the mine infrastructure is being maintained and there is reason to believe that operations could be resumed in the future. An *intermittent* status is only used with placer deposit records and indicates that an area has historically hosted sporadic

small-scale placer operations, which is expected to continue. *Prospect* describes a site where a resource is identified and is expected to continue to attract development interest. Dual status indicators are used in conjunction with records for complex deposit sites. A *closed/prospect* status thus denotes a site where an earlier mining operation has been permanently shut down but the presence of additional resources has been identified.

The **best source** field, which Long and others (1998) introduced, is retained. The field identifies sources where production, resource and surface information can be found and used to update values given in the database. Typical sources include company Internet web sites, annual company financial reports, mandatory reports filed with governmental regulatory authorities, and published annual summaries of mining industry activities.

Conclusions

A total of 256 significant deposit sites are identified, 127 in Montana, 119 in Idaho, 8 in Oregon and 2 in Washington. They represent 50 deposit-types, an unclassified group, and one site simply identified as tailings. The deposit-type with the largest representation is placer Au with 32 examples; however, the placer sites are geographically large areas better characterized as districts rather than deposits. Of the remaining 49 deposit-types, 31 are represented by two or fewer examples. Deposit-types represented by 3 or more examples include hot spring Au-Ag (16 examples); distal disseminated Au-Ag (13); Au bearing skarn (12); Revett Cu (12); upwelling phosphate (12); polymetallic replacement (8); Au-Ag-Te veins (7); Blackbird Cu-Co (6); epithermal vein, quartz-adularia (5); and low sulfide; Au-quartz veins (4). There are also (14) examples of porphyry type deposits: (5) porphyry Cu-Mo, (5) porphyry Mo, low-F, (2) porphyry Cu-Au, and (2) porphyry Mo, Climax. The remaining 57 sites fall into some category of polymetallic vein, with the largest single group being Coeur d'Alene polymetallic veins with (25) examples. The remaining (32) are scattered among a host of variants of polymetallic veins.

Of the 256 significant deposit sites, 208 have some history of productivity. The productive sites include 23 currently active mines, 41 sites where operations are either inactive or intermittent, and 144 where mining has exhausted the initially identified resources and mining has ceased. Inactive sites include those sites where a substantial reserve remains and the mine workings and surface facilities are being maintained, so that production can resume with a minimum of delay, when economic circumstances are more favorable. The intermittent status applies to sites where mining occurs sporadically over time. All of the placer Au sites are so categorized along with a few of the gem and industrial mineral commodity sites. In terms of resource potential and future productivity, 190 of the 256 sites have an identified resource present. This group includes the 64 active, inactive and intermittent sites, and 126 prospects of which 78 have been previously mined and are now closed and 48 are pure prospects. Of the 190 sites, 139 contain a resource that is of significant size in terms of its contained commodity content or contains more than one million short tons of mineralized rock.

In terms of near-term development potential, not all of the 190 sites are of equal importance. The mere presence of a significant commodity endowment does not guarantee that a deposit will or can be developed. Technologic and economic factors, not taken into consideration in the definition of a significant deposit are important in determining whether a deposit is economically viable. Two such examples are the Southern Bohels Butte Anorthosite and the Woodrat Mountain Kyanite Area. These sites contain enormous resources of aluminum (Al) and kyanite respectively, however, the cost of recovering aluminum from anorthosite is not competitive with recovery from bauxite ores, which remain plentiful, and the remote location of the kyanite resource from potential users places it at an economic disadvantage with less distant sources. Determining the relative importance of the identified significant deposits to near-term development interest cannot be solely based on the single criteria of the endowment present.

References

- Bliss, J.D., 1992, Developments in mineral deposit modeling: U.S. Geological Survey Bulletin 2004, 168 p.
- Bliss, J.D., 1994, Grade, tonnage, and other models of Blue Mountain-type Au-Ag polymetallic veins, Blue Mountains, Oregon, for use in resource and environmental assessment: U.S. Geological Survey open-file report; 94-677, 33 p.
- Bultman, Mark W., 1991, Quantitative mineral resource assessment of selected mineral deposits in the Challis National Forest, Idaho: U.S. Geological Survey Bulletin 1987, 25 p.

- Cox, D.P., Lindsey, D.A., Singer, D.A., and Diggles, M.F., 2003, Sediment-hosted copper deposits of the world: deposit models and database: U.S. Geological Survey open-file report; 03-107, 49 p.
- Cox, D.P. and Singer, D.A., 1986, Mineral deposit models: U.S. Geological Survey Bulletin 1693, 379 p.
- DuBray, E.A., ed., 1995, Preliminary compilation of geoenvironmental mineral deposit models: U.S. Geological Survey Open-File Report 95-831, 272p.
- Høy, Trygve, 1996, Irish-type carbonate-hosted Zn-Pb: in Lefebure, D.V. and Høy, T, eds, Selected British Columbia Mineral Deposit Profiles, Volume 2 - Metallic Deposits, British Columbia Ministry of Employment and Investment, Open File 1996-13, pages 21-24.
- Long, K.R., DeYoung, J.H., Jr., and Ludington, S.D., 1998, Database of significant deposits of gold, silver, copper, lead, and zinc in the United States; Part B: Digital database: U.S. Geological Survey Open-File Report 98-206B, 1 3.5-inch floppy diskette
- Long, K.R., personal communication
- Ludington, S.D. and Cox, D.P., eds., 1996, Data base for a national mineral-resource assessment of undiscovered deposits of gold, silver, copper, lead, and zinc in the conterminous United States: U.S. Geological Survey Open-File Report 96-96, 1 CD-ROM
- Orris, G.J. and Bliss, J.D., 1992, Industrial minerals deposit models: grade and tonnage models: U.S. Geological Survey Open-File Report 92-437, 84 p.
- Orris, G.J. and Bliss, J.D., 1991, Some industrial mineral deposit models: descriptive deposit models: U.S. Geological Survey Open-File Report 91-11A, 73 p.
- Ray, G. E., 1995, Mo skarns: in Lefebure, D.V. and Ray, G.E., eds, Selected British Columbia Mineral Deposit Profiles, Volume 1 - Metallics and Coal, British Columbia Ministry of Energy of Employment and Investment, Open File 1995-20, pages 77-78.
- Singer, D.A., 1995, World class base and precious metal deposits; a quantitative analyses: *Economic Geology*, v. 90, no. 1, p. 88-104.
- Stoeser, D. B. and Heran, W. D., eds., 2000, USGS mineral deposit models: U.S. Geological Survey Digital Data Series DDS-064 Version 1.0 2000.
- Theodore, Ted G., 2000, Geology of pluton-related gold mineralization at Battle Mountain, Nevada: Monographs in mineral resource science; no. 2, Center for Mineral Resources, The University of Arizona, 271 p.
- U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a Resource/Reserve Classification for Minerals: U.S. Geological Survey Circular 831, 5 p.